Non-Equilibrium Asymmetric Thermoelectrics (NEAT)

TRACK E1

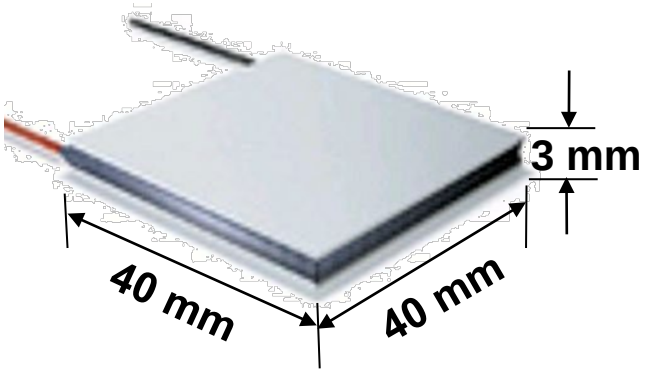
ARPA-E Building Cooling Project Spotlights

March 2, 2011

Traditional Thermoelectrics

Merits

- Solid-State technology
- No moving parts
- Green, no GHGs
- Light
- Silent



Drawbacks

- Material properties (ZT < 1) limit efficiency of coolers
- System designs are archaic
- High $/W for cooling power
- Scale mismatch and high heat flux limit thin film TECs to microscopic applications

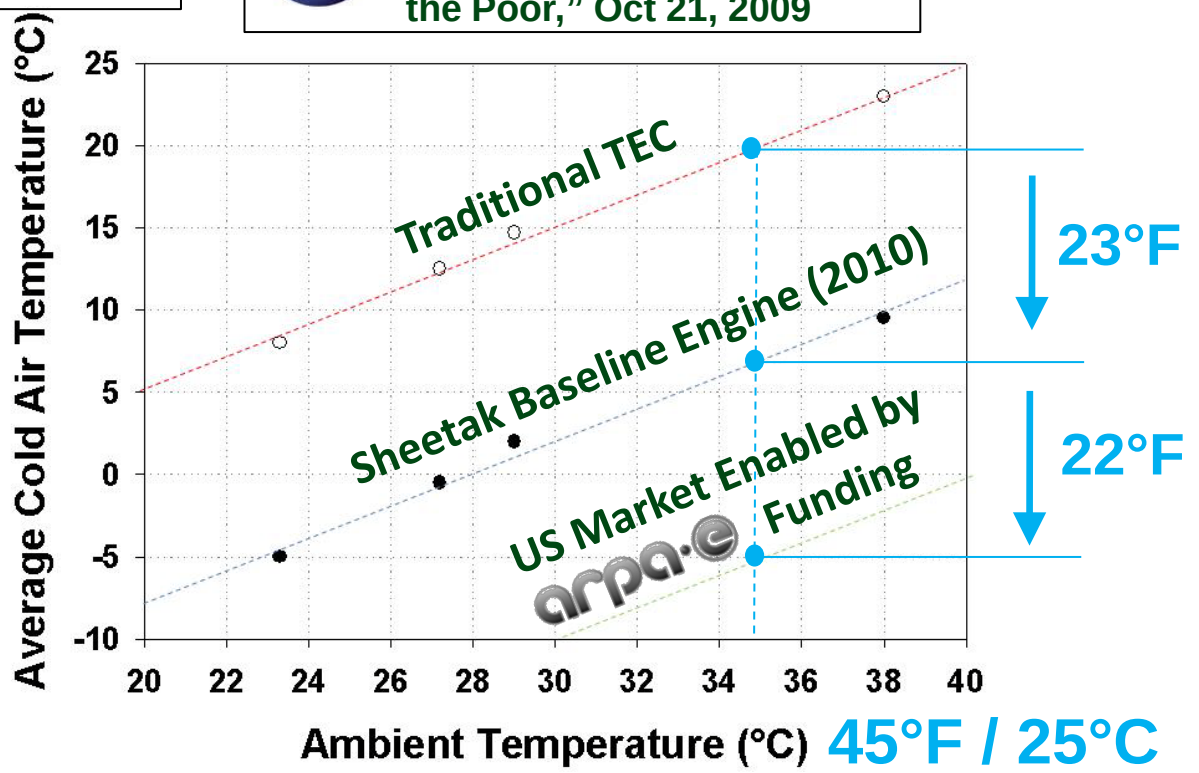
Practical applications will require Sheetak's efficient and low-cost thermoelectrics

Refrigerator for the Bottom Billions

Harvard Business Review — "New Business Models in Emerging Markets," Jan-Feb 2011

WSJ.com THE WALL STREET JOURNAL. — "Indian Firms Shift Focus to the Poor," Oct 21, 2009

DESIGNED & ENGINEERED IN THE USA



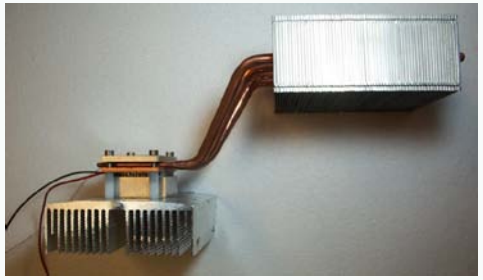
45°F / 25°C cooler temperature!

Sheetak's engines enable India's lowest cost refrigerator

Core Technologies

NOVEL HEAT CIRCUITS

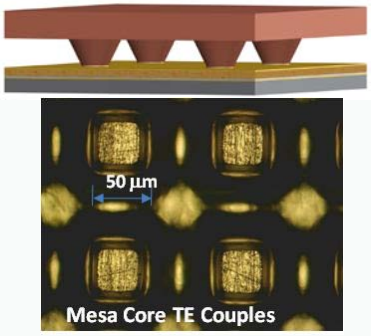
Heat Diodes, Transformers, Capacitors



commercialized

HIE THERMOELECTRICS

Nanostructured, Low Cost TEC ZT~2



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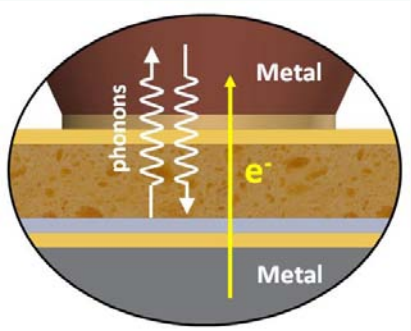
NEAT

Non-Equilibrium TE, Phonon Blocking

ZT~4



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Cooling engines incorporating core technologies enable efficient solid-state refrigeration

Refrigeration and Air-Conditioning

2010 System Technology

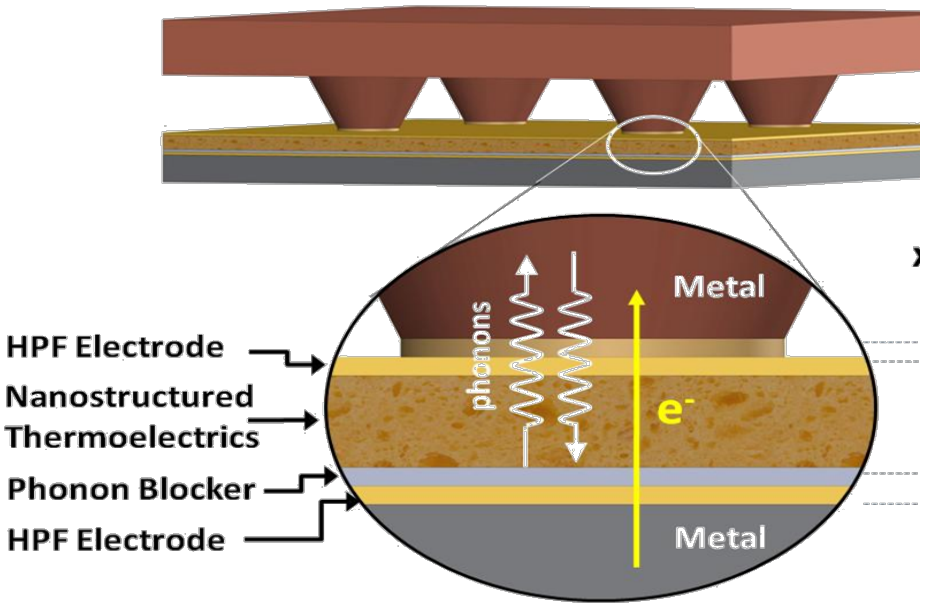
2011 HiE Systems

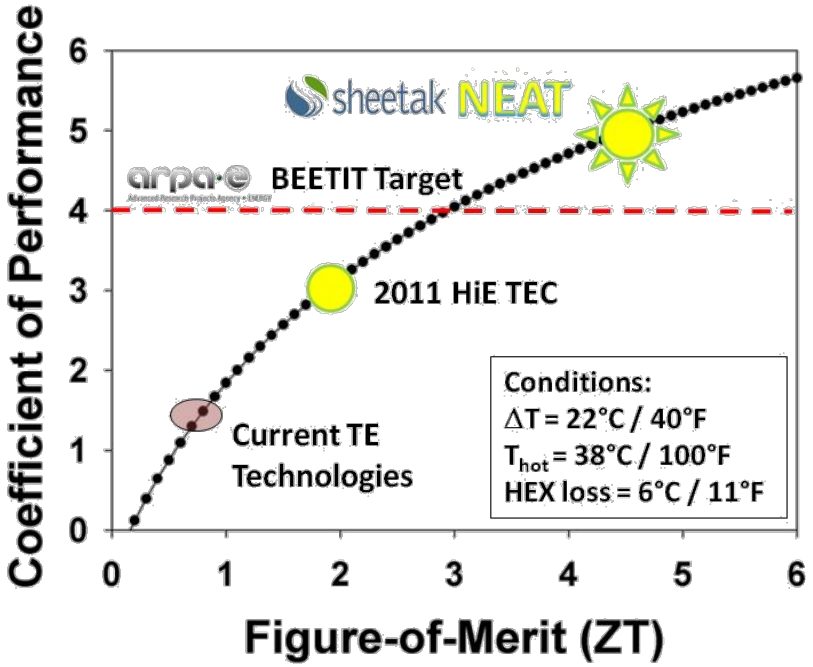
2012 NEAT Systems

NEAT devices will make Sheetak technologies competitive in global air-conditioning markets

High-Efficiency Solid-State Electronic Cooling

- Novel electrodes to reduce interface losses
- Non-equilibrium effects decouple electron and phonon systems
- Atomically-thin phonon-blocking (PB), electron tunneling junctions





- **~50% cost savings on the AC hardware**
- **No polluting greenhouse HFC or CHFC gases**
- **Lower weight and volume**